been forthcoming, the interest has flagged in recent years, perhaps only temporarily.

There is no space here to report extensively on the contents of the individual articles. This reader found the paper by H. Kahn a very readable introduction to Monte Carlo sampling techniques. The paper by O. Taussky and J. Todd contains a particularly useful exposition of the generation of random sequences. H. F. Trotter and J. W. Tukey have contributed an article on "Conditional Monte Carlo for normal samples" which contains some very clever ideas by means of which the sample size necessary for satisfactory accuracy is reduced by the factor 5000 in a statistical application reported by H. J. Arnold, B. D. Bucher, H. F. Trotter and J. W. Tukey. The first of these two papers is rather difficult to read, partly because its authors adopt the extremely colloquial style frequently met in work on Monte Carlo. The results of J. H. Curtiss concerning the relative efficiency of Monte Carlo procedures and ordinary numerical methods for the solution of systems of linear algebraic equations raises the hope that there is still a future for Monte Carlo in this particular field.

This volume is almost indispensable to mathematicians doing research on or with Monte Carlo methods, and it can be highly recommended to readers who wish to find out what the Monte Carlo method really is.

WOLFGANG WASOW

Automata studies. Edited by C. E. Shannon and J. McCarthy, Princeton, New Jersey, Princeton University Press, 1956, viii +285 pp. $4.00.

This collection of essays is divided into three sections: "Finite Automata," "Turing Machines," and "Synthesis of Automata." We will discuss the first two sections together and take up the third later.

The essays in these two sections treat mainly the mathematical and logical theory of quantized or discrete automata, as contrasted with analog machines. The automata of the first section have a fixed number of elements and states, while those of the second section have a changing, but always finite, number of states. An equally basic division is into *deterministic* and *probabilistic* automata, according to whether the state of an automaton is a deterministic or probabilistic function of the preceding state (including the inputs); this classification crosses the one used by the editors (e.g., there are two kinds of deterministic automata, fixed automata and Turing machines). Since realizability by a deterministic automaton is equivalent to (partial) recursiveness, the essays of these two sections are all contributions to the logic of recursive functions. Some are concerned with recursiveness in general, others with the special kind of recursiveness involved in fixed automata, and the remainder with extending the theory of recursiveness to include probabilistic considerations in fixed automata and Turing machines.

A discrete, fixed, deterministic nerve net is a useful model for studying the human brain. S. C. Kleene's *Representation of events in nerve nets and finite automata* is one of the most important papers in the volume. In it Kleene investigates the logic of such nets, particularly the classes of past histories that a nerve net can detect in the sense that there is a net junction which is active at a given time if and only if the history of the inputs up to this time belongs to the given class. He defines a concept of "regular" and shows that any regular class of histories is detectable and conversely. M. L. Minsky's *Some universal elements for finite automata* and J. Culbertson's *Some uneconomical robots* are also concerned with nerve nets. Minsky characterizes some sets of elements that are sufficient to construct all neural nets; we will comment on Culbertson's paper in connection with the third section.

E. F. Moore's paper, *Gedanken-experiments on sequential machines*, is concerned with finite, deterministic automata in general. He specifies ways of deducing the detailed internal structure of an automaton from some general information about its structure and detailed information about its response to various inputs.

John von Neumann's *Probabilistic logics and synthesis of reliable organisms from unreliable components* is another very important paper. It is a study of methods of synthesizing fixed, probabilistic automata whose overall reliability is greater than the reliability of their parts. A novel method of accomplishing this—called multiplexing—is introduced, and quantitative results concerning its effectiveness are established. This paper contains many suggestive ideas. K. de Leeuw, E. F. Moore, C. E. Shannon, and N. Shapiro in *Computability by probabilistic machines* also treat probabilistic automata; they investigate the extent to which adding a random element to a Turing machine increases its powers.

Three other papers on (deterministic) Turing machines complete the first two sections of the volume: C. E. Shannon, *A universal Turing machine with two internal states*, M. D. Davis, *A note on universal Turing machines*, and John McCarthy, *The inversion of functions defined by Turing machines*.

The third section, *Synthesis of automata*, contains four papers on the general problem of designing automata to perform human functions: W. R. Ashby, *Design for an intelligence-amplifier*, D. M. MacKay, *The epistemological problem for automata*, and two papers by Albert M. Uttley, *Conditional probability machines and conditioned reflexes* and *Temporal and spatial patterns in a conditional probability machine*. Culbertson's paper in the first section also makes many remarks pertinent to this area.

We can think of the various possible stimuli presented by an environment as input states to an automaton, and the human reactions to these stimuli as output states of an automaton. For example, in language translation the input is a Russian text, the output is an English translation of it. A basic theoretical problem is to describe the stimuli and human responses to them with sufficient precision and detail that the relation between inputs and outputs may be expressed as recursive or statistical functions. Not any recursive function will do; it must be one simple enough to be exemplified in an existing machine or a machine that can be built. Thus, complexity is one factor, but it is not the only one. For example, there does not now exist a precise description (of any complexity) of the relation between Russian and English suitable for automatic translation. The point can be put this way: there exist machines which are potentially capable of performing many human functions which they cannot now perform because there do not exist programs (sequences of instructions) which tell the machines how to perform these functions.

These problems, which clearly belong to applied rather than pure mathematics, are very difficult and complicated. What is needed are specific formulations of ways in which automata could perform the more complicated human functions. MacKay recognizes this need, and gives valuable specific suggestions on how to make an automaton learn new concepts. Culbertson seems to be unaware of this need. Thus he says, "we will describe a general method for designing robots with any specified behavior properties whatsoever. They can be designed to do *any* desired physically possible thing under any given circumstances and past experience, and certainly any naturally given 'robot,' such as Smith or Jones, can do no more" (p. 110). His "general method" consists merely of showing how to construct a special type of net without cycles!

Ashby tackles the problem of constructing an automaton which can do original thinking. He suggests using a random source for producing a tremendous number of possible solutions to a problem and then using an equilibrium method for selecting a correct one. That leaves untouched the difficult problem of formulating mechanical criteria for selecting a correct answer from so many wrong ones in a given field. In view of the difficulty of this problem, it is not clear that his is the best way to approach the overall problem of designing an automaton with originality. Perhaps it is better to produce fewer more promising possibilities than to produce so many wild ones.

ARTHUR W. BURKS

BRIEF MENTION

Theory of approximation. By N. I. Achieser. Trans. from the Russian by Charles J. Hyman. New York, Frederick Ungar, 1956. 10+307 pp. $8.50.

For a review of the German translation of this work, cf. this Bulletin, vol. 61, pp. 369–371.

Foundations of the theory of probability. By A. N. Kolmogorov. 2d English edition. Trans. from the German by Nathan Morrison, with an added bibliography by A. T. Bharucha-Reid. New York, Chelsea, 1956. 8+84 pp. $2.50.

A translation of the classic Ergebnisse monograph of 1933.

The theory of groups. Vol. II. By A. G. Kurosh. Trans. from the 2d Russian edition by K. A. Hirsch, with supplementary material by the translator. New York, Chelsea, 1956. 308 pp. $4.95.

For Vol. I, cf. this Bulletin, vol. 62, p. 277. This second and last volume includes Part III: *Group-theoretical constructions*, and Part IV: *Solvable and nilpotent groups.*

Contributions to the theory of nonlinear oscillations. Vol. III. Ed. by S. Lefschetz. Annals of Math. Studies no. 36, Princeton University Press, 1956. 7+285 pp. $4.00.

This collection contains papers by G. Seifert, L. Markus, E. Pinney, V. B. Haas, R. E. Gomory, S. Barocio, F. Haas, G. Hufford, W. T. Kyner, S. P. Diliberto, M. D. Marcus, and P. Koosis.

Proceedings of the conference on differential equations, held at the University of Maryland, March 17–19, 1955. Ed. by J. B. Diaz and L. E. Payne. College Park, University of Maryland Book Store, 1956. 12+294 pp.

This collection contains papers by W. M. Whyburn, S. Bochner, E. Hopf, M. Riesz, J. B. Diaz and G. S. S. Ludford, M. H. Protter, E. T. Copson, Y. W. Chen, G. Szegö, A. Huber, Z. Nehari, L. Amerio,